

Mid Infrared Laser Sources for Remote Sensing

Completed Technology Project (2016 - 2017)



Project Introduction

Mid infrared solid-state lasers are made possible by using innovative low phonon energy materials. Until recently, such lasers were not feasible because they characteristically had a short upper laser level lifetime. Thus, they were unable to store much energy and accumulate a high laser gain. By using a low phonon energy laser materials, nonradiative losses from the upper laser level can be minimized. In turn, the upper laser manifold lifetime increases, thus the laser gain. An innovative laser design can also be used with mid infrared lasers to provide enhanced detection capabilities. As a principle of parsimony with provided funding it is wise to choose the best candidates to examine first. These would be Pr and Dy for targeting CH₄ (methane) and CO. Using earlier spectroscopic studies, lasers can be designed to operate on MIR transitions in low phonon materials. If successful, MIR lasers can be further developed for a variety of Ln³⁺ ions in low phonon hosts to address various MIR spectral regions. The impact is clear and in the MIR region, broad spectral coverage buys access to chemical "fingerprints," where molecules can be detected and distinguished with great sensitivity. In fact, the region of the MIR from 3 to 10 μm has distinct 'Fingerprint Regions' of interest for remote sensing, specifically 3-5 & 7-10 μm .

Anticipated Benefits

The main objective is to demonstrate mid infrared (MIR) lasers for active remote sensing applications. Two factors work in favor of such instruments: (1) MIR atmospheric absorption bands in the 2–10 μm region are very wide and consist of large numbers of narrow and relatively equally spaced spectral lines and (2) MIR emission bands of lanthanide (Ln³⁺) are also wide, providing the tunable lasers to address atmospheric absorption. For example, Pr (praseodymium) lasers operating around 2.5 and 5 μm can target CO (carbon monoxide) and N₂O (nitrous oxide). Previous work done at Langley indicate lanthanide series elements, Pr, Dy, Er, and Ho can be incorporated in low phonon hosts like LaF₃ and KPb₂Cl₅ to produce MIR lasers. Laser demonstrations in the MIR remain in their infancy, with just a few examples to date. Such efforts can be of substantial benefit to NASA in exploring the MIR spectral ranges, rich in many atmospheric molecular gasses. Regarding detectors on the remote sensing measurement end, the field continues to develop in parallel with MIR lasers. APD's (Avalanche Photo Diodes) based on narrow-gap II-V semiconductors are being developed in the 2-5 μm range. New materials like HgTe have exhibited room temperature photo response > 5 μm .



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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

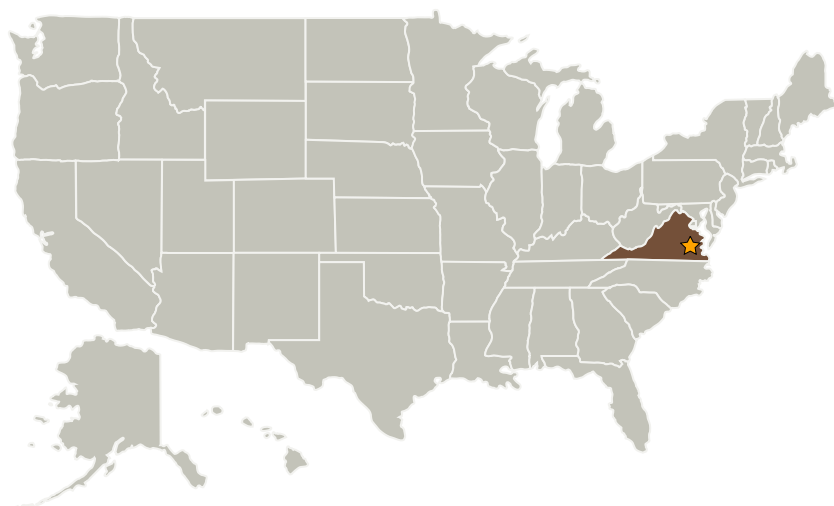
Center Innovation Fund: LaRC CIF

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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Langley Research Center (LaRC)	Lead Organization	NASA Center	Hampton, Virginia
Hampton University	Supporting Organization	Academia Historically Black Colleges and Universities (HBCU)	Hampton, Virginia

Primary U.S. Work Locations

Virginia

Project Management

Program Director:

Michael R Lapointe

Program Manager:

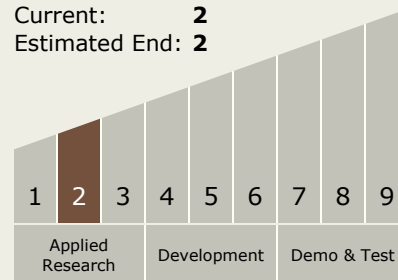
Julie A Williams-byrd

Principal Investigator:

Brian M Walsh

Technology Maturity (TRL)

Start: 2
 Current: 2
 Estimated End: 2



Technology Areas

Primary:

- TX08 Sensors and Instruments
 - └ TX08.1 Remote Sensing Instruments/Sensors
 - └ TX08.1.5 Lasers

Target Destination

Earth